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WADC TECHNICAL REPORT 52-79, PART 1

STUDIES IN CUE UTILIZATION BEHAVIOR

Part 1. The Influence of a Relevant but "Unused" Cue in Training Upon Transfer in a Positive Transfer Situation

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AERO MEDICAL LABORATORY

APRIL 1952

WRIGHT AIR DEVELOPMENT CENTER

AF-WP-(B)-O-12 125

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Part 1. The Influence of a Relevant but "Unused" Cue in Training Upon Transfer in a Positive Transfer Situation

Gordon A. Eckstrand
Aero Medical Laboratory

April 1952

RDO No. 694-44

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

FOREWORD

This report was prepared by the Psycholcgy Branch of the Aero Medical Laboratory, Research Division, Wright Air Development Center, under a project identified by Research and Development Order No. 694-44, Design of Training Devices, with Dr. Gordon A. Eckstrand acting as Project Engineer. The experimental data were collected at Ohio State University, Columbus, Ohio, under Contract No. AF 33(038)-15474 and under the direction of Dr. Delos D. Wickens.

ABSTRACT

In a training device or simulator an attempt is made to provide the primary stimulus cues which exist in the operational equipment or situation for which the student is being trained. In a simulator, however, additional or secondary cues may be introduced unintentionally which the student can use to obtain successful performance. If such secondary cues are available and used by the student, will he also learn to use those which are primary and must be relied upon in the operational situation? In four separate experiments directed toward this question subjects learned, on the basis of a secondary cue, a task which also contained a "primary" cue. They were then forced to perform the task on the basis of the "primary" cue alone. Their performance was compared with that of subjects who had not experienced the "primary" cue during learning. The results of these experiments support the hypothesis that little or nothing is learned about performing a task on the basis of the "primary" cue while learning is occurring on the basis of a secondary cue. The results point-up the potential inadequacy of any training device which permits successful performance in the device on the basis of cues other than those which permit successful performance in the operational situation.

PUBLICATION REVIEW

Manuscript copy of this report has been reviewed and found satisfactory for publication.

FOR THE COMMANDING GENERAL:

Robert H. Blount
ROBERT H. BLOUNT
Colonel, USAF (MC)
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I. INTRODUCTION

In a previous report (3) attention was directed toward the role of a training task in teaching the trainee cue attention habits, i.e., habits of attending to and utilizing certain of the cues available in a task situation while neglecting others. The results of the previous study supported the conclusion that cue attention habits established during training may transfer to the learning of later, similar tasks and exert a selective influence upon which of the cues in the second task are utilized. This research indicates the importance of designing the proper cues and the proper cue relevance patterns into training aids and devices.

Another question concerning the importance of the stimulus situation in training devices is pointed up by the following example which was used in the report referred to above. One of the training devices used during World War II was a device designed to teach range estimation to gunners. This trainer involved the use of a model airplane whose apparent range could be varied. Practice on this device was intended to teach gunners to make accurate estimations of the range of an aircraft on the basis of its apparent size. However, an experimental study of this device demonstrated that learning proceeded as rapidly with the model plane absent as with the plane present, indicating that apparent changes in the size of the plane did not constitute the only cue to range estimation in the trainer. Apparently other cues were available which were relevant to successful performance on the device.[1] Now the question pertinent to the design of training devices is this; what effects do these "supplementary" or "secondary" cues have on the effectiveness of the training received on this device? Assuming that all trainees utilize the secondary cues in learning the task presented by the training device, will they learn anything about the relationship between apparent size and range? It is possible, of course, that the trainees will learn nothing about the relationship of apparent size to range while attending to some other cue. However, it is also possible that effective training of this nature will result even under these conditions since the plane (and hence the size cue) is always present at the time the range judgment is made. In this situation, then, the cue which is relevant to successful performance in the operational situation is also present and relevant in the training device, but other cues, not present in the operational situation, are present and relevant also. In view of the ease with which secondary cues may be introduced inadvertently into a training device, and in view of the great amount of discussion concerning their effects, it seems highly desirable to investigate this situation experimentally.

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1. In this report the term relevant cue refers to a stimulus dimension (size, color, form, etc.) which is correlated with successful performance on a task, i.e., can be used to learn the task; an irrelevant cue refers to a stimulus dimension which is uncorrelated with successful performance on the task, i.e. cannot be used to learn the task.

The general question involves consideration of whether all stimuli acting at the time of response become associated with the response, or whether only those stimuli which are "attended to" become associated with the response. Since it is obvious that no stimulus can enter into learning unless it is perceptually available to the learner, the general question stated above can be investigated meaningfully only for that situation in which all cues are stimulating the learner in a discriminable manner. For experimental purposes the question may be simplified and stated as follows; when a task in which two relevant cues are available is learned on the basis of one of these cues, does the person learn anything about performing the task correctly using the other relevant cue?

II. THEORETICAL BACKGROUND

The general question considered above is not new in the history of learning psychology. A long and involved controversy in the study of discrimination learning in animals has centered about the question of whether or not associations are formed between relevant cue and the appropriate responses when solutions to the discrimination problem are being attempted or responses made on the basis of some other cue or cues. Two sharply contrasting theories have provided different answers. The non-continuity theory of discrimination learning states that no associations are formed between the relevant cue and the appropriate responses until the attempted solution is one that depends upon this cue. The continuity theory, on the other hand, states that whenever cues which fall on the sensorium so as to provide discriminably different stimulation are contiguous with the appropriate responses, associations are formed between the responses and the cues regardless of whether or not these cues are being "attended to." An example will make the differences between these two theories clear. Let us assume that a rat is placed in a box from which two alleys emerge, a black alley and a white alley. The rat is to learn to run always into the black alley and is rewarded with food each time that he does so. No food is given when he runs into the white alley. Half of the time the black alley is on the right and half of the time the white alley is on the right. Now let us further assume that our rat begins the problem with a spatial hypothesis, e.g., he always runs to the right regardless of which alley is there. The question is, will the animal learn anything about the correctness or wrongness of the color stimuli while it is responding to a position cue? Non-continuity theorists answer that the animal will learn nothing about the correctness or wrongness of the color stimuli until it begins to respond systematically in terms of these stimuli. Continuity theorists answer that so long as the animal received discriminably different stimulation from the color stimuli, some degree of association between this cue and the correct responses would result regardless of the cue to which the animal is responding.

A test of these two formulations which has been agreed upon by proponents of both theories is provided by reversing the reward value of the color stimuli while the animal is still responding to some other cue and then determining whether or not the subsequent learning of the reversed problem is retarded. In the example used above this would involve rewarding the animal when he runs into the white alley and not when he runs into the black alley. The non-continuity theory would predict that such a reversal would not interfere with the learning since the animal has formed no associations between the color cue and the responses required. The continuity theory, on the other hand, would predict that the learning of the reversed problem would be retarded since the animal has formed stimulus-response associations in the pre-reversal training which lead to erroneous responses after reversal. These erroneous response tendencies must be "unlearned" before the correct stimulus-response associations can be learned.

A number of animal studies using the experimental procedure described above have been performed (1, 4, 5, 6, 8). Without reviewing this literature in detail it may be said that, in general, the results of these studies have supported a continuity interpretation of discrimination learning in animals.

The two theories described above would, of course, give different answers to our question regarding human learning. The question again is this; when a task in which two relevant cues are available is learned on the basis of one of these cues, does the person learn anything about performing the task correctly using the other relevant cue? If extended to cover this situation, it is believed that non-continuity theory would answer "no", continuity theory "yes". However, such an unqualified extension to the human learning situation is not justified at this time. Both theories were derived from studies of the learning of animals under rather specific conditions, and these same restrictions must apply to the explanatory and predictive power of these theories. Questions concerning the seeming continuity or discontinuity of human learning under different conditions must be answered by empirical investigation with human subjects and it should be emphasized that the results of such investigations do not bear on the validity of these theories as formulated by their proponents. At best such investigations can only provide answers to specific questions, serve to define the limits within which the present theories can be extended in an unmodified form, and provide some information concerning the modifications necessary to make one or the other theory applicable in the new area.

Few investigations concerning the ability of humans to utilize the cues available in a learning situation have been conducted. The study most relevant to the present discussion is one performed by Prentice (7). His technique was quite similar to that employed in the animal studies cited above. Two groups of human subjects were taught to make a conditional visual discrimination. One group learned this problem to a criterion without any previous training whereas the other group was given twenty prior trials on the opposite problem, i.e., responses which were considered to be correct on the final problem were incorrect during the preliminary trials and vice versa. This latter group took a significantly greater number of trials to solve the problem (when the twenty preliminary trials were included in their score) than did the other group even when all subjects who had showed any signs of attending to the relevant cue before reversal were dropped from consideration. This result was interpreted as supporting a continuity interpretation of human discrimination learning, since no retardation in rate of learning would be predicted on the basis of non-continuity theory. On the other hand, the decrement in rate of learning which was found was less than would be predicted on the basis of non-continuity theory. On the other hand, the decrement in rate of learning which was found was less than would be predicted on the basis of continuity theory, so such an interpretation is not completely adequate either. The results of this indicate the need for much more experimental data in this area before an approach can be made to formulating the conditions under which human learning can be considered continuous or discontinuous.

III. PURPOSE OF PRESENT STUDY

The question to be investigated in this study implies an experimental procedure which is somewhat different from that used in previous studies in this area. The animal studies and the human study cited earlier asked the question, when an organism is responding (unsuccessfully) to irrelevant cues in a problem situation, does it learn anything about performing the task correctly on the basis of the relevant cue? The test for such learning, it will be remembered, was reversing the correctness of the relevant cue stimuli and determining whether or not the learning of the reversed problem was retarded. Our question is, when a task in which two relevant cues are available is learned (i.e., the person is responding <u>successfully</u>) on the basis of one of these cues, does the person learn anything about performing the task correctly using the other relevant cue? The test for such learning in this case will be to remove the cue to which the individual has been responding and determine whether or not the learning of the problem thus modified is facilitated.[1] If any associations have been formed between the additional relevant cue and the required responses, learning of the modified problem should be facilitated since these same cue-response associations are required in the modified task. If no associations have been formed between the additional relevant cue and the required responses, learning of the modified problem should be neither facilitated or retarded. As was mentioned previously, the latter problem is the one most relevant to the design of training devices. However, this investigation is similar to those described above in that it bears on the general question of whether all stimuli acting at the time of response become associated with the response, or whether only those stimuli which are "attended to" become associated with the response.

IV. METHOD

Apparatus:

The apparatus used in this study was the same as that previously described in connection with another study (2) except that no shield covered the keys.

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1. The demonstration of facilitation or lack of facilitation implies, of course, the availability of appropriate "control" data for comparison purposes. The techniques for providing such data are described below under <u>Plan of the Experiment</u>.

Briefly, the apparatus consisted of a vertical display panel containing a small aperture approximately at eye-level and a horizontal reaction panel containing a starting key and four reaction keys. A 40-step stepping switch was mounted behind the display panel. By mounting an aluminum disc on the shaft of the stepping switch and placing 40 stimuli at proper intervals around the perimeter of the disc, it was possible to present a continuous series of stimuli to the subject (S). Different series of stimuli could be presented simply by preparing other discs and changing them as required.

The apparatus was wired so that there was a fixed connection between a particular stimulus aspect appearing in the aperture and a particular reaction key. The S's task was that of learning to associate each of the four reaction keys with its appropriate stimulus aspect. If the correct reaction key was depressed, a new stimulus appeared in the aperture when S returned to the starting key. If an incorrect key was depressed, no new stimulus appeared when S returned to the starting key and he had to continue in his attempts to select the correct key.

An Esterline-Angus, operations recorder was connected with the apparatus in such a way that a complete record of S's correct and incorrect responses could be obtained from the recording tape.

Stimulus Materials:

The stimuli used in this experiment were outline forms and letters drawn on construction paper of various colors.[1] Thus when S saw a stimulus in the aperture he could respond to the form, the letter, the color or perhaps to some combination of these cues. As will be explained below, in one of the tasks only two of these cues were present. By arranging the stimuli on the discs in different ways, it was possible to make any one of the three cues relevant while the other two were irrelevant, to make any two of the cues relevant while the third was irrelevant, and in the cases where only two cues were present, to make either one relevant while the other was irrelevant. For example, by arranging the forms on the stimulus disc in such a way that each of the four forms used had a fixed connection with one of the four response keys and by assigning colors and letters to the forms in a random manner, it was possible to make form a relevant cue and color and letter irrelevant cues, i.e., the task could be learned by utilizing the forms but not by utilizing the colors or letters. By pairing form and color in a systematic manner, arranging them on the disc properly, and assigning letters to the form-color combinations in a random manner, it was possible to construct a task in which both form and color were relevant and letter irrelevant. In a similar manner, it was possible to prepare discs representing other cue relevance conditions.

1. The forms used were relatively unmeaningful and were mutually discriminable. Standard construction paper colors which were mutually discriminable were used. The letters used were capital letters from the English alphabet. The forms, letters and colors used in the experiment are shown in Appendix A.

Plan of the Experiment:

Basically this experiment consisted of having two groups of Ss learn a Criterion Task consisting of one relevant cue and one irrelevant cue after having had different prior experience. For the experimental group, this prior experience consisted of learning a task identical with the criterion task except that a second relevant cue was present. This cue will be called the secondary relevant cue. For the control group the prior experience consisted of learning a task in which both of the cues present in the Criterion Task were irrelevant and another relevant cue was present (this cue was the same as the secondary relevant cue for the experimental group). Comparisons were made between the speed with which the control and experimental groups learned the Criterion Task. For purposes of this comparison only those experimental group Ss who learn the Prior Task on the basis of the secondary relevant cue were used. Thus, the experimental and the control groups both learned the Prior Task on the basis of the same cue, but the cue which was relevant in the Criterion Task was present as an additional relevant cue for the experimental group whereas it was present and irrelevant for the control group. Thus, while learning the Prior Task, the experimental group had an opportunity to learn the cue-response associations which were required in the Criterion Task, whereas no such opportunity was afforded the control group. If such learning occurred in the Prior Task, it should evidence itself in a superiority of the experimental group over the control group in learning the Criterion Task. If no such learning occurred, there should be no difference in the rate with which the control and experimental groups learned the Criterion Task.

It was desirable to have some method of maximizing the probability that Ss in the experimental group would learn the Prior Task on the basis of the secondary cue, since only Ss who learned on the basis of this cue could be used in the critical comparisons. In the previous study (3) it was shown that Ss could be taught to learn a task on the basis of a certain cue by giving them prior experience with other, similar tasks in which that same cue was relevant. In this study this same technique was used. Before learning the Prior Task, each S learned two Cue-Training Tasks involving colors, letters and forms. Different colors, letters and forms were used in these two training tasks and these in turn were different than those used in the Prior Task, but in both the training tasks the secondary relevant cue in the Prior Task was the only relevant cue. It was felt that this training would result in most of the experimental group learning the Prior Task on the basis of the secondary relevant cue and minimize the use of multiple cue hypothesis.[1]

With three cues available (color, form and letter) it was possible to set up six different Prior Task-Criterion Task conditions. Four of these were selected for use in this study. These four conditions along with the training tasks used are blocked out in Table I.

1. The forms, colors and letters used in each of the tasks are presented in Appendix A.

TABLE I

Outline of Conditions Used in Study

Condition	Task	Experimental Group Color	Form	Letter	Control Group Color	Form	Letter
I	T1	I	I	R	I	I	R
	T2	I	I	R	I	I	R
	P	I	R	R	I	I	R
	C	I	R		I	R	
II	T1	I	R	I	I	R	I
	T2	I	R	I	I	R	I
	P	I	R	R	I	R	I
	C	I		R	I		R
III	T1	I	R	I	I	R	I
	T2	I	R	I	I	R	I
	P	R	R	I	I	R	I
	C	R		I	R		I
IV	T1	I	I	R	I	I	R
	T2	I	I	R	I	I	R
	P	R	I	R	I	I	R
	C	R	I		R	I	

T1 - Cue-Training Task 1, T2 - Cue-Training Task 2, P - Prior Task, C - Criterion Task, R - Relevant, I - Irrelevant

From Table I it can be seen that this study consisted of four separate experiments which can be analyzed separately and independently.

Procedure:

The Ss used in this experiment were 200 students from the elementary psychology classes at Ohio State University; 25 Ss in each of eight groups. The procedures and the instructions for the Ss in the control and experimental groups and in each of the four separate conditions investigated were the same. After S was seated properly in front of the apparatus, the nature of the task to be performed was explained and demonstrated. S was told that there was a certain fixed connection between a particular choice key and a particular characteristic or part of the stimulus which would appear in the aperture. It was explained that the task was to learn which key to press when a particular stimulus characteristic or part appeared in the aperture.

After the directions were completed, S learned Cue-Training Task 1 to a criterion of 10 consecutive errorless responses. A two minute rest period was allowed at the end of each 40 trials. If S had not reached the criterion after 160 trials he was dismissed from the experiment.[1] S waited outside the room while the disc was changed and then returned to learn Cue-Training Task 2 to a criterion of 10 consecutive errorless responses. The same procedure was followed before the learning of the Prior Task and the Criterion Task, and each of these tasks was also learned to a 10 consecutive errorless response criterion, except that a minimum of 25 trials was given on the Criterion Task. This was done in order to make an error analysis possible on this final task.

Since Cue-Training Task 2 was the last task which was identical for the control and experimental groups, this task was used as the matching task. Ss were assigned to the control and experimental groups in each condition in such a way that they were matched (mean and variance) for number of trials to learn Cue-Training Task 2.

At the conclusion of each task, S was nonchalantly asked how he had solved the problem. Information concerning the cue used was, of course, needed only for the Prior Task, but the question was asked following all tasks so as not to make the Prior Task distinctive.

For all tasks the number of trials required to reach the criterion was recorded for each S. For the Criterion Task a record was also kept of the number of errors made during the first 25 trials.

V. RESULTS

Matching of Groups:

It will be remembered that the experimental and control groups were equated on the basis of their learning scores on Cue-Training Task 2. The matching data are presented in Table II.[2]

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1. If S appeared to be on the verge of achieving the criterion at the end of 160 trials he was allowed to continue until he reached the criterion or until the experimenter was satisfied that he did not have the correct hypothesis. This task turned out to be particularly difficult and approximately one-third of the Ss tested failed to learn it. Consequently, approximately 300 Ss had to be run in order to obtain the required number of Ss in each group. No S failed to learn any of the other tasks.

2. Similar data on the learning of Cue-Training Task 1 and the Prior Task are presented in Appendix B.

TABLE II

Comparison of Number of Trials to Learn Cue-Training Task 2 For the Control and Experimental Groups of Each Condition

Group	Condition							
	I		II		III		IV	
	M	V	M	V	M	V	M	V
Control	29.88	180.98	40.68	481.66	46.12	644.98	28.24	247.78
Experimental	28.76	173.14	41.64	305.59	46.44	626.08	27.52	341.77

M - Mean, V - Variance

Within each of the four conditions it can be seen that the experimental and control groups are quite well matched for both mean and variance. None of the differences between the means or the variances for the control and experimental groups within each of the four conditions even approach statistical significance.

Learning of the Criterion Task:

The data relevant to the experimental question are those which allow comparisons between the control and experimental groups in each of the conditions on the following measures;[1]

1. Number of trials required to learn the Criterion Task to a 10 consecutive errorless response criterion.

2. Number of errors made during the first 25 trials on the Criterion Task.[2]

If the experimental groups require fewer trials to learn the Criterion Task than the corresponding control groups, we have evidence for the fact that the Ss did learn something about performing the task on the basis of the additional relevant cue while responding to the secondary cue. The same type of statement holds true for the error scores. If no such differences exist between control and experimental groups, we have evidence for the fact that the Ss learned little or nothing about performing the task on the basis of the additional relevant cue while responding to the secondary cue.

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1. It will be remembered that only those experimental group Ss who learned the Prior Task on the basis of the secondary cue could be used in these comparisons. That the cue training tasks were successful in establishing the desired cue attention habits is evidenced by the fact that more than 86% of the experimental group learned the Prior Task on the basis of the secondary cue.

2. Even if a S reached the criterion before 25 trials, he was continued until 25 trials had been completed. Thus all Ss had at least 25 trials on the Criterion Task.

TABLE III

Comparison of Number of Trials to Learn the Criterion Task for the Control and Experimental Groups of each Condition

Group	Condition							
	I		II		III		IV	
	M	σ_M	M	σ_M	M	σ_M	M	σ_M
Control	29.20	3.26	29.96	5.01	38.24	3.88	40.28	6.99
Experimental	27.32	2.89	33.88	4.96	33.32	3.60	41.60	5.94

M - Mean, σ_M - Standard Error of Mean

These data show that in conditions II and IV the control group learned the Criterion Task more rapidly than the experimental group, and in conditions I and III, the experimental group learned the Criterion Task faster than the control group. In all cases, however, the differences are small relative to the standard errors of the means. In order to evaluate the significance of the differences between control and experimental groups in each condition the t-test was utilized. The results of this statistical comparison are given in Table IV, the sign of the mean difference indicating whether the experimental group learned faster (+) or slower (-) than the corresponding control group.

TABLE IV

Differences and t-Ratios Between Control and Experimental Groups in Each Condition for Number of Trials to Learn the Criterion Task

Condition	Mean Difference	t-Ratio
I	+1.88	0.43
II	-3.92	0.56
III	+4.92	0.93
IV	-1.32	0.14

It is readily apparent from this table that none of the differences even approach statistical significance.

The mean number of errors made during the first 25 trials of learning the Criterion Task for the control and experimental groups of each condition is presented in Table V.

TABLE V

Comparison of Number of Errors Made in the First 25 Trials of Learning the Criterion Task for the Control and Experimental Groups of Each Condition

Group	Condition							
	I		II		III		IV	
	M	σ_M	M	σ_M	M	σ_M	M	σ_M
Control	6.96	0.82	5.88	0.77	10.28	1.00	8.64	1.13
Experimental	5.92	0.64	6.88	0.88	8.16	1.15	9.12	1.21

M - Mean, σ_M - Standard Error of Mean

These data indicate much the same picture as the trials-to-learn data. In conditions II and IV the control group made fewer errors than the experimental group, while the experimental group made fewer errors than the control group in conditions I and III. Again the differences were relatively small. However, t-tests were run in order to evaluate the significance of the differences. The results of this analysis are given in Table VI, the direction of the difference being indicated by the sign as in Table IV.

TABLE VI

Differences and t-Ratios Between Control and Experimental Groups in each Condition for Number of Errors in Learning the Criterion Task

Condition	Mean Difference	t-Ratio
I	+1.04	1.00
II	-1.00	0.85
III	+2.12	1.39
IV	-0.48	0.29

Again it can be seen that none of these differences approach statistical significance. Thus, neither the analysis of the trials-to-learn data nor the analysis of the error data will allow a rejection of the null hypothesis, i.e., none of the data gathered in this experiment will allow us to reject the hypothesis that no difference exists between the control and experimental groups in each condition.

VI. DISCUSSION

The results of this experiment support the hypothesis that when a discriminative motor task involving two relevant visual cues is learned on the basis of one of these cues (secondary), apparently little or nothing is learned about performing this task on the basis of the other relevant cue (primary). This conclusion holds true for all four conditions investigated in this study. Since these conditions involve several patterns of primary and secondary cues, it is felt that this conclusion has at least some generality. In condition I, letter is the secondary cue and form the primary cue; in condition II, form is the secondary cue and letter the primary cue; in condition III, form is the secondary cue and color the primary cue; and in condition IV, letter is the secondary cue and color the primary cue. Thus in one case we have a primary cue consisting of highly meaningful, highly familiar symbols (letters), in another case consisting of relatively unmeaningful, unfamiliar symbols (forms), and in the other two cases of stimuli which are highly familiar but which require no pattern or form perception as in the other cases (colors). It seems probable from this analysis that the primary cues used represent several degrees of perceptual complexity. To the extent that this variable is represented, however, it appears not to be an important one.

The validity of the conclusion stated above depends, of course, upon our having used an adequate test for any learning which might occur in the experimental group. In this study the test consisted of removing the secondary cue and forcing the experimental group to learn the task on the basis of the primary cue. Their learning performance was compared to that of a group who had not previously experienced the primary cue as an additional relevant cue. It might be argued that the experimental group did learn something about performing the task on the basis of the primary cue but that this test was not sensitive enough to demonstrate this learning. Indeed, when one looks at the variability within groups it is apparent that the differences between control and experimental groups would have to be fairly large in order to be statistically significant. However, this hypothesis becomes quite tenuous when one remembers that the control group actually learned the Criterion Task faster than the experimental group in two of the four comparisons. The lack of statistical significance of the mean differences along with the even split in the direction of the differences renders the hypothesis that the experimental group learned anything about the primary one quite untenable.

It was previously noted that the experimental design used in this study was different from that used in previous studies on the continuity, non-continuity problem. Previous studies have investigated the effects of a period of pre-solution training on a discrimination task on the later learning of the reversed task. This pre-solution period is defined by the fact that the organism is responding to irrelevant cues in a problem situation involving one relevant cue. This, of course, means that by definition the organism is responding unsuccessfully during this period of training. The present study involved no such pre-solution period, no such period of unsuccessful responding. Rather, the period of training preceding the critical test consisted of responding successfully to one relevant cue while another relevant cue was present. Thus although both types of studies are concerned with the same general question, this difference exists and may be an important one. Certainly this should be one of the variables investigated in any program of research designed to relate task variables and cue utilization behavior.

Possibly another factor of significance in this study is the use of the two cue-training tasks. Presumably these tasks taught the Ss to "pay attention to" one of the three stimulus dimensions present and to disregard or neglect the other two dimensions. Before learning the Prior Task all the Ss had experienced considerable success in solving tasks of this nature by utilizing only one of the three available cues. It is possible that this experience affected the ability of the experimental group to profit from the presence of the additional relevant cue in the Prior Task. In other words, different results might be obtained if no attempt was made to establish "cue-attention habits" in the Ss before the learning of the Prior Task. This possibility should most certainly be investigated.

VII. SIGNIFICANCE OF RESULTS FOR TRAINER DESIGN

It is apparent that the results of this research have implications for the design of training equipment. These results point-up very definitely the potential inadequacy of any training device which permits successful performance in the device on the basis of cues other than those which permit successful performance in the operational situation. It is not enough to be assured that the relevant cues from the operational situation have been simulated accurately in the training device; for even though this be the case, little or no training with respect to these cues may result if the trainee learns the task presented by the training device on the basis of some additional relevant cue. Let us take an example. One of the important uses of present day flight simulators is in providing instruction for aircrew members in emergency procedures; i.e., instruction in the recognition of an proper procedures for correcting troubles which may occur in the many aircraft systems. In order to provide training in the detection and recognition of such troubles it is, of course, necessary to simulate the distinctive cues which signal the occurrence of various kinds of trouble in the actual aircraft. The very process of simulation, however, could result in some additional cue being inadvertently introduced into the trainer. For example, a relay click or some other distinctive noise may invariably precede or accompany the occurrence of the simulated cues. If the student uses this cue (which is p eculiar to the simulator) to detect and recognize the trouble, he will be able to perform adequately on the simulator but may learn nothing which can be effectively transferred to performance in the full scale aircraft.

The results of this study along with a consideration of the ease with which secondary cues may be inadvertently introduced into a training device point to the need for alertness in preventing or eliminating such cues on the part of those who design, build, accept, or evaluate training equipment.

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APPENDIX A

TABLE VII

Forms, Colors, and Letters Used
in Each of the Experimental Tasks

CUE TRAINING TASK 1	FORMS				
	COLORS	RED	LIGHT GREEN	BROWN	CREAM
	LETTERS	H	M	B	T
CUE TRAINING TASK 2	FORMS				
	COLORS	TAN	BLUE	PINK	DARK GREEN
	LETTERS	V	S	C	J
PRIOR AND CRITERION TASKS	FORMS				
	COLORS	PURPLE	ORANGE	GREY	YELLOW
	LETTERS	X	U	F	N

APPENDIX B

TABLE VIII

Comparison of Number of Trials to Learn Cue-Training Task 1
for the Control and Experimental Groups of Each Condition

Group	Conditions							
	I		II		III		IV	
	M	σ_M	M	σ_M	M	σ_M	M	σ_M
Control	74.92	8.16	97.12	9.37	88.44	9.98	68.44	8.45
Experimental	75.08	10.41	106.32	9.62	77.72	9.44	93.04	8.14

M - Mean σ_M - Standard error of mean

TABLE IX

Comparison of Number of Trials to Learn the Prior Task
for the Control and Experimental Groups of Each Condition

Group	Conditions							
	I		II		III		IV	
	M	σ_M	M	σ_M	M	σ_M	M	σ_M
Control	49.56	8.19	40.36	4.97	47.96	6.91	36.52	4.79
Experimental	27.72	3.04	36.20	3.62	28.40	2.26	22.96	1.83

M - Mean σ_M - Standard error of mean